Institute of
Engineering Thermodynamics

Current progress in the design and setup of a SOFC/GT hybrid power plant

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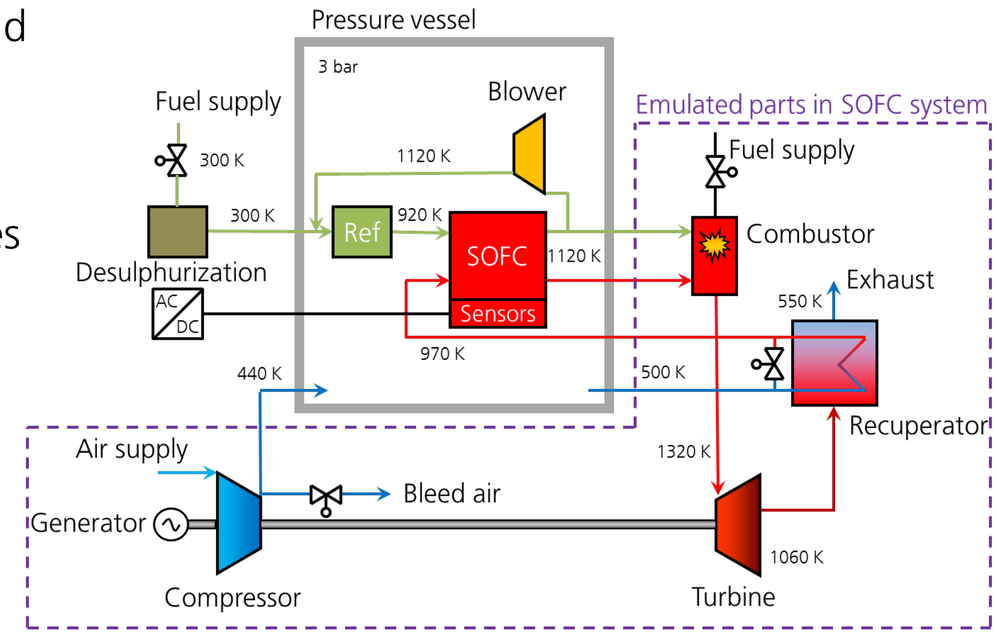
Concept

- Combination of SOFC and micro gas turbine (MGT)
- SOFC exhaust drives gas turbine and compressor
- MGT compressor provides part of air preheating
- Pressurized SOFC

Advantages

- High electrical efficiency
- Fuel flexibility (hydrogen, natural gas and biogas)
- Scalability
- Wide operating range

Solid Oxide Fuel Cell (SOFC) system



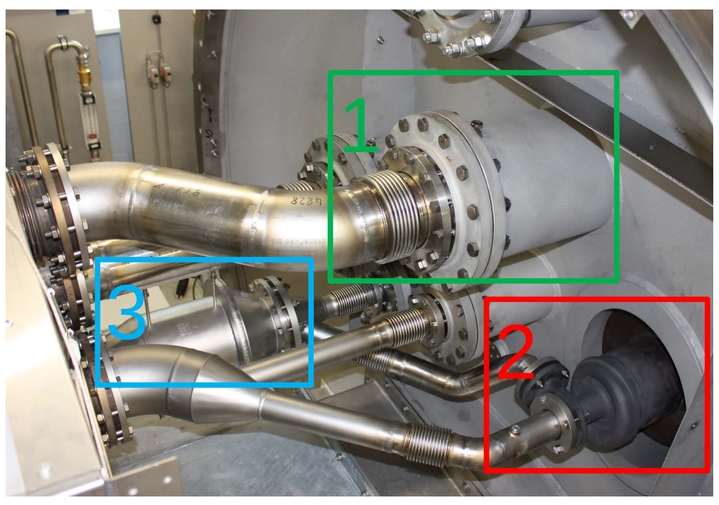
Assembly of two emulation test rigs prior to hybrid power plant at DLR

- Test rig for the SOFC with emulated gas turbine
- In parallel build up of gas turbine test rig at Institute of Combustion Technology
- SOFC (30 kW_{el}) from sunfire GmbH
- Gas turbine (30 kW_{el}) from Micro Turbine Technology (MTT)
- Operating pressure up to 0.3 MPa
- Anode gas recirculation with high temperature blower from CAP Co., Ltd.
- Pressure vessel from FCT Systeme GmbH

Technical challenges:

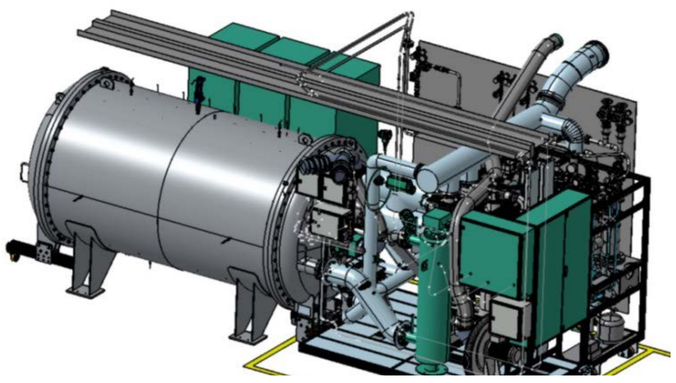
1. SOFC is operated under pressurized conditions
2. SOFC is sensitive for fast pressure changes and pressure differences
3. Minimizing heat losses at high operation temperatures (up to 1120 K)
4. Natural gas and biogas need reforming and preheating without carbon deposition
5. Dynamic operation characteristics of SOFC and gas turbine differ significantly

SOFC on vessel drawer



Design choices:

1. SOFC located in a pressure vessel for pressurized operation
2. SOFC designed for inner pressure differences up to 50 mbar. The control strategy keeps pressure differences on lowest possible value
3. Vessel feed-through (1) with three-layer-system insulates gases to vessel casing. The piping length is minimized
4. Anode gas recirculation with a blower (2) provides steam and heat for the steam reforming in the reformer (3)
5. Elaborate system control with interconnected control loops for system protection



Model of SOFC with emulated GT

Further system component:

- Electric load for grid feed-in and automated switchover to resistor load during power blackout

SOFC system:

- Emulates gas turbine components with an electric heater, a catalytic after burner, heat exchangers and air compressor

Electric load

Outlook:

- Start-up of the system with debugging and optimization of the control loops
- Characterization of SOFC system with emulated gas turbine
- Revision of hybrid power plant system design and system details
- Development of hybrid power plant interfaces and merge of control units and concepts
- Start-up of combined hybrid power plant with SOFC and gas turbine

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